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A dynamic model for adjusting contemporary construction projects behaviors in today changeable environments

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Abstract

Project Management knowledge has been used in many project oriented organizations in last two decades across the world. Despite, rate of project success did not change during these years. We believe there is a basic challenge in projects environment for managing them based on its inherent characteristics. In fact, project management knowledge use theories and concepts that are belong to process management world, as a different world. There is no enough attention to project characteristics as a fundamental differentiation for coping projects. Identification of construction projects nature in order to discern variables that create the project behaviors is main concern of the paper.Considering project characteristics in this research revealed construction project nature creates from combination two aspects. First, detecting environmental changes to develop a need and second prepare resources structure to respond the need. Important management challenge in this model is environmental continuous changes that alter the need and exchange resources structure. So, the paper considers how these aspects can be operationalized for developing a dynamic project management model. It gives some ideas about why project complexity might be considered to be increasing, and how construction projects move towards shorter timescales. The effectiveness of the model is verified by applying it for predicting some construction projects behavior. The results of the paper may capable future project managers to test any decision before its applying and lead to a new project management tool for construction projects management.

Keywords: *Environmental changes, Dynamic project management model, Project nature, Project theory, Construction projects performance.*

1. Introduction

Since 1980, many researchers, institutes and practitioners in various industries focused on using project management knowledge and have analyzed how to successfully manage projects. Among them is the Standish Group, which regularly publishes its findings in its Chaos reports for computer world and IT industry. In 1994, Standish reported a shocking 16 percent project success rate, another 53 percent of the projects were challenged, and 31 percent failed outright. [1] In subsequent report, in 2004, Standish updated its findings, 29 percent project success rate, another 53 percent of the projects were challenged, and 18 percent failed and in the latest report, in 2009, 32 percent project success rate, 44 percent of the projects were challenged, and 24 percent failed. [2] These reports as an only organized review for changing project management results present not desired effectiveness for project management methods that have been applied during last year's.

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In another industries, there is no organized reports for review periodically project management results, but there are not desired results overall. Examples of failed large, complex projects include the U.S. Navy's development of the Littoral Combat Ship that is currently $100 million over the original budget estimates. The Channel Tunnel connecting Great Britain and France that when completed was approximately $10 billion over its original budget and two years late. the Boston Central Artery project that is approximately $10 billion over its original budget and seven years late and the U.S. Department of Energy's National Ignition Facility that exceeded the original budget by approximately $1 billion and was six years late. [3]

Aside from these facts, there are divergence variances on trend of scheduling and budgeting of the national construction projects in Iran. As illustrated in Table 1, average completed project duration of national construction projects in Iran is 11.04 years; in spite of average scheduled duration of it that is 3.57 years. [4] In other words, average variance of national construction projects is nearly % 300 that is extravagant challenge that does not changed in the last decade.

The traditional project management methods are proving inadequate and the new methods of analysis and management are needed. [5] Cicmil et al. argue that what is needed to improve project management in practice is not use of traditional project management practices. [6] They state while a great deal is written about traditional project management, we know very little about the actuality of project. So, we believed that more implementation of current project management methodology could not improve results of project management and rethinking about project management methodologies is so critical. he aim of this paper is that a better understanding of project nature and the causes of project behavior to building infrastructures of the intended theoretical developments in the project management field, specific in construction projects Results of the research's model can use to predict of construction projects outcomes for scheduling, budgeting, complexity control and the client satisfaction changes during project lifecycle.

Table 1 Average variance of national construction projects in Iran

Year	Completed Project Duration Average (Years)	Anticipated Project Duration Weighted Average (Years)	Scheduled Duration Average (Years)	Variance Percentage Average
2004 (1382-Hijri calendar)	11.2	7.8	3.6	% 311
2005 (1383-Hijri calendar)	9.4	7.9	3.6	% 261
2006 (1384-Hijri calendar)	11.3	7.7	3.3	% 342
2007 (1385-Hijri calendar)	10.1	8.6	3.1	% 326
2008 (1386-Hijri calendar)	10.7	9.9	2.6	% 412
2009 (1387-Hijri calendar)	11.9	11.6	4.4	% 270
2010 (1388-Hijri calendar)	12.7	10.3	4.4	% 289
Average	11.04	9.11	3.57	% 309

2. Background of Project Management Knowledge Deficiencies

There has been much effort to explain how projects should be managed in their environments by taking account of different contingency factors [7,8,9].

Koskela and Howell argued that in the analysis of project management research, spanning forty years [12], have nothing to report on the theory of project management. They stated the poverty of current theory explains the other problems of project management, such as frequent project failures [13], lack of commitment towards project management methods [14] and slow rate of methodological renewal [15]. Also, Kujala, Artto and Parhankangas believed that the focus on theory development is for challenging the assumption that there is a universal and standard guideline for managing projects. [16] Turner and Cochrane argued that different types of projects should be handled differently, depending on the quality of project goals and methods definition. [17]

Furthermore, Koskela and Howell argued that the present doctrine of project management suffers from serious deficiencies in its theoretical base. [12] They believed implicit theory of project management that is derived the theories of general management, rests on a faulty understanding of the nature of work in projects, and deficient definitions of planning, execution and control. They suggest transformation, flow of work and value generation as fundamental theories for developing project management theory. [18] In addition, Fox and Skitmore believed there has been a virtually complete lack of theoretical development in the construction projects management crucially. They contribute to this theoretical development by identifying the six contributing factors based on a questionnaire survey. [19]

Soderlund stated that much project management research has been devoted to the search for the generic factors of project success. [20] He stated theories of projects are conceptualizations and models that explain and predict the structure and behavior of projects, and in order to further develop the project field a number of such theories would need to be presented, some complementary, some competing.

In the last years, some another authors attempt to follow the general research topic about project theory under various titles. For instance, andersen proposed a theory for internal renewal projects that constitute four elements contain boundaries, outputs, processes and input that related these four elements to projects success. [21] He claimed that we can consider the temporary organization as a production entity that converts input into desired outputs via a variety of production processes.

Sauer and Reich believe that management researchers should create and test theories that respond to specific issues and leave integration of these theories to generalize for all kind of projects until later. [22] They contend that different kinds of theory have different attributes. They believe instead of regret for lacking of theory in project management, researchers should make a plea for the development and use of explanatory and predictive theory in specific domain of project management. They stated one of the general weaknesses of normative theory is its defect to do according to the theory as deviations. It offers no insight into why the deviation has occurred nor how to correct it. Hence, there is a requirement for developing theories with constrained scope to understand the factors that produce behaviors and how these behaviors can change by controlling the root causes. Also, project behaviors analysis by the theories with constrained scope and limited variables is easier

Sauser et al. believed that the root cause of the project failure usually is embedded in management's failure to choose the right approach to the particular project. [23] The evolving field of project management contingency theory to investigate the consistency between project characteristics and project management approach present new insight for developing novel concepts and innovative project management models. They suggest more analysis of project's unique characteristics to found new conceptions on project success and develop new contingency frameworks. Developing a fundamental framework for planning and managing a project conform to its unique characteristics may correct rate of success in contemporary project management environment and outlining the new fundamental researches in the discipline. Sauser et al. desired next researches could predict success or failure and even provide warning signals in an on-going project.

Geraldi et al. analyzed project success from another perspective and proposed three pillars for responding to unexpected events by project managers. [24] They argue that uncertainty is essential characteristic of projects and so ability to manage unexpected events is a vital capability for all project managers. In recent years, Kapsali similar to Andersen research [21], investigated innovation project management as a specific area of projects.[25] She examine systems thinking role in more success of innovation projects and criticizes why conventional project management approach lead to the failure generally. Kapsali believes that conventional project management methods, such as detailed planning, formalized communication and tight controls, do not manage fundamental characteristic of innovation projects, because they restrained boundaries of innovativeness and communication to change. She also suggested future researches about how to embed flexibility in project management methods.

Moreover, Killen et al. proposed the application of strategic management theories to project management in following previous researches for enriching theoretical basis of project management knowledge. [26] They used the Resource-Based View (RBV), the Dynamic Capability (DC) concept and the Absorptive Capacity (AC) concept for advancing project management researches and provide examples and guidance for theory development in this field. Although research approach of Killen et al. has a considerable idea for adopting project management theories from the strategic management domain, but they did not attend to distinctive nature of projects in regard to the processes and proposed the project management position as a subset of general management and strategic management researches. In fact, they did not consider project's unique characteristics and thought project management is similar to process management in general management field.

3. Research Methodology

An important source to identifying the fundamental variables and interaction between them in project environment is practitioners' view and their experience, besides scientific literatures. Calori, proposes 'pragmatic epistemology' as a methodological framework that use practitioners and researchers as a research team in co-authoring theories and creating knowledge which is immediate, pragmatic and contextualized.[27] Cicmil et al. in their survey for researching actuality of projects, use this approach as the research methodology. [6] Also, Walker et al. emphasized on the importance of reflection in learning by understanding theory through challenging it and testing it in the practical ways. [28]

An appropriate research approach, therefore, to inferring causes of projects behaviors and recognizes interactions between project variables to better understanding of project nature is based on co-authorship. Co-authorship enables theory building by combining scholarly theorizing and practitioners' narratives. [6] The practitioners in this methodology are secondary source to discover new variables or relationships that influence on project behaviors. This source also uses to formulate assumptions and relationships in order to comparison with their own experience in contemporary projects.

Project management has varied domain with practitioners in different industries like defence, automotive, engineering, construction, food, aerospace, etc industries. Moreover, there are different project types in each industry. Based on previous researches suggestions [22, 23, 25], we select construction industry as a specific purpose to analyze factors that produce projects behaviors and examine probably differentiation between project types in this industry, include building construction, road construction, dam construction, general site grading, massive earthwork projects and private investment projects.

In above categorization, we use combination of the common three types of construction projects include building, heavy construction and industrial with the three type introduced by Whittaker include manual projects, machinery projects and mind projects. [29] This paper, in fact, investigate building and heavy projects from the first categorization and mind projects as a replacement for industrial projects from the second categorization to cover usual construction projects with more details, machinery projects with more complexity and research projects with more uncertainty and change. We applied this categorization to start the comparison of construction projects and now believe the results of the paper are applicable for another construction projects, due to consider fundamental characteristics of the construction projects for developing the final model.

As initial step in data gathering, we chose 5 Iranian corporations include Public Corporation (to operate under government control) and Private Corporation in each selected construction type (building construction, road construction, general site grading and massive earthwork projects, dam construction and private investment projects) and distribute a questionnaires between all project managers of those corporations for gathering detailed quantitative data on each project. We target 107 construction projects, but attain 63 complete answers from participated project managers. Then, we arrange a long range research plan for recording and considering the projects behaviors in each project types. All the projects ranged in budget from $7.5 million to $1.5 billion and in duration from 1 to 4 years. After two years, 26 projects have been held in suspense due to two main reasons include lack of resources and initial assumptions changes. So, we continue our study with 37 active projects. Data gathering has been done during 3 years.

The projects behaviors monitored in scheduling, budgeting, stakeholders' satisfaction and employees' reflection during the research. Recording project realities and identifying variables that produce the realities was a research goal that following in an empirical part of the study for understanding practitioners' challenges. During this recording, we developed many unstructured interview with project practitioners include project manager, site executive, schedule manager, cost engineers, budget manager, architect and design engineers, even top organizational managers and other stakeholders in client organizations, consultant organizations and contractors organizations, for examine any factors that could influence on project results.

Second part of this research belongs to review the research articles that implicit or explicit discuss on project theory in the last 20 years. We analyze the leading scholar's researches to find structure that make project behavior. Aim of this survey was recognized fundamental characteristics of projects that distinguish project nature versus process, because of commonly use of general management tools in project management without focus on the differentiation.

In order to create final model, finding of previous researchers should integrate with intellectual exploration of the project nature analysis based on practitioners' challenges and factors that change project behaviors. Hence, Variables and their relationships defined based on theoretical considerations and empirical studies on practitioners' experiences. After some corrections in formulation of interaction between variables, the model of project behavior completed and presented the final version to practitioners' evaluation. Practitioners compared the real project variance in the real world with the model structure and its predictions about their project behaviors during eight months at two periods. Finally, results of the research and the variables that influence project behaviors utilize to propose the methodology for planning and managing contemporary construction projects especially in developing country with increasingly rate of environmental changes. The proposed methodology could apply to intended theoretical developments in the construction project management knowledge and will contribute to more satisfactory outcomes of contemporary construction projects.

4. Analysis Of Construction Projects Nature

Project management outcomes did not improved, despite of increasingly utilize of project management knowledge in the last decade. [3, 5, 6, 23] This issue reveals an essential challenge in conventional project management approach and exposes a necessity to re-examine the mutual consistency between identity as project and its management style. In other words, we think there is fundamental difference between project nature and its characteristics with general management toolbox that apply to project environment in conventional project management methods. The aim of this section is rethinking the construction project nature to re-define the project characteristics and identify control variables of project behavior. We believed that better understanding projects identity is a vital necessity for performance management of contemporary construction projects.

4.1. Protean nature of construction projects

There is a common description of the project that define it as a temporary endeavor with a defined beginning and end (usually time-constrained, and often constrained by funding or deliverables), undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value. The transient nature of projects positions it in contrast with process or usual operations as subject of general management which is cyclic and permanent functional activities to produce products or services. [30] Essentially, the management of these natures should be completely different and require the development of distinct management strategies. In addition to mentioned definition, in the last years, Turner presented an upgraded definition that characterize a project as a temporary organization to which resources are assigned to do work to deliver beneficial change. [31]

To analyze construction project nature and better understanding of its characteristics, there is a necessity to consider making process of the identity. Each construction project creates based on a need by client. The needs establish on macro environment changes that influence on desired effects of client. Client goals and demands define on achievable potentially options in the client's environment. Therefore, nature of client goals and demands are changeable and dynamic conform to rate of project environmental changes. Hence, in order to manage project goals changes, there is a requirement to measure dynamics rate of macro environment changes that influence on project include at least political, economical, social and technical environments.

Macro environment changes, special technical environment changes, affect defined methods to achieve construction project goals and could make better solutions to perform project activities. So, project executives would like to follow up these changes to improve their methods of implementation tasks for creating competitive advantages. On the other hand, environmental changes interest client to use potentially improved alternatives and thereupon change project goals. These changes interest project professional executives like consultants and contractors to improve their competitive advantages once again and change project methods during the contract. So, projects are always susceptible of continuous change from up to down due to client desire and down to up due to executives' desire. This protean nature of project forming during the project and conform to its environmental changes rate. This concept lead project scope creeps as a project feature in the traditional project management to project scope jumping as a characteristic of contemporary construction projects that illustrate in Fig. 1.

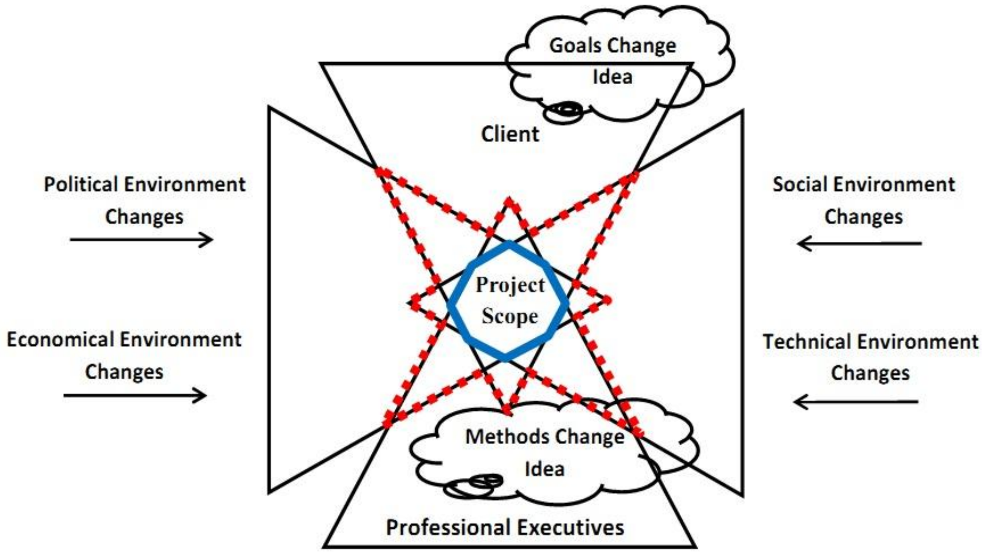


Fig. 1 Continuous changes of project scope caused by continuous changes of environmental assumptions

4.2. Contracts deficiency

Conventional project management models often designed based on prepare baseline plan for doing defined commitments in project initiative stage. In these models, comparison between proceed contractual commitments and initial plan perform after execute project activities and re-plan process accomplish when any variance occurs toward plan. In this condition, the control process or required correction actions do for reducing variance regard to the plan. This approach just focus on time and budget and neglect consider environmental factors to improve performance and better stakeholder satisfaction. So, even the risk management method in the conventional procedures often implement in order to avoid project cost and time overruns.

In the circumstances, project management just considers project performance in comparison with the initiate plan and do not manage project needs based on the substantial mission of the management science for improving efficiency and effectivity based on new occasions. Conventional project management models under the circumstances convert to a contracts administrative system rather than managing projects. In other words, project activities in the conventional models administrate in the frame of its initiate contract and do not sufficient attention to project nature dynamics and changeable project assumptions.

This conventional system lead project management team attempts to respond to froze contractual needs at project start date and distract careful attention of project manager from changing environment, changing potentially options and changing project assumptions to initial defined needs in the contract at the start date. Indeed, in static contractual management method many environmental considerations and analysis that could influence on better project planning by take in opportunities during project accomplishment will neglect due to there are out of contract commitments of the project planners.

So, today seems static contractual management method that determines definite project needs and expectations is in contrast with new requirements to manage new characteristics of construction projects environment such as continuous environmental changes and project goals' uncertainty. Repetitious review of project goals and methods could recur project scope changes and so will change project scheduling and budgeting.

4.3. Critical role of stakeholders

Construction projects nature consideration showed that all staff and teams in project environment regardless of their hierarchy or formal position in the project organization delineate project outcome and performance equal to their power. So, to manage project behaviors must manage project stakeholders' behaviors and this area has a fundamental role in today project management knowledge, more than its previous importance. This manifold importance formed based on two project characteristics: first, multiple interactions between increasing project components and second protean nature of contemporary construction projects due to increasing environmental changes. Hence, lead project behavior in changing environment and shifty project goals to obtain stakeholders' satisfaction need stakeholders' management as a fundamental area for managing today construction projects.

4.4. Project complexity

Williams in the research about new paradigms for managing project complexity indicates two factors for increasing project complexity. [32] First is the number and interdependence of elements based on Baccarini research [33] and second is uncertainty in goals and means based on Turner and Cochrane paper. [34] In their papers, they believe that project complexity as a characteristic of contemporary projects is increasing because of enlarge number of project elements and thereupon a greater degree of inter-element connectivity. Also, increasing interest to tighten scheduling due to raising competitions is another origin to changing goals and means and so more complexity in today projects.

Therefore, managing project behaviors require managing number of project elements and reduce interdependence of project elements by suitable organizing. Whereas increasing number of construction projects elements is inevitable due to more specialism, managing project complexity is possible by simplify inter-element connectivity and centralize task commitments as a flat organization. Construction projects often are human based projects with multi teams work that managing their commitment and participation is very complicated. In fact, often there are many teams work in construction projects that inter connectivity between them with many mutual responsibilities create complexity for measuring the teams commitment. Flat organizing by define independent work groups with autonomous operation could help to better responsibility in project environment.

Project complexity will conduct to create chaos in projects and so prevail project passive planning. Therefore, new characteristic of today projects is the complexity that increased due to utilizing component oriented trend, like the PMBOK guide or ISO 21500, in the conventional project management. This component oriented approach for managing today projects is one of complicator factor that leads increasing complexity of project management methods and so, rate of contemporary projects management failure. So, reduce project complexity is an important requirement for strategic management of contemporary projects.

Whereas today projects show considerable variation, their specific management styles remain without any distinction yet. In the circumstances, identifying simple structure of fundamental factors that create projects behavior could help to manage strategic performance of contemporary construction projects.

5. Projects Behavior Pattern Recognition (PBPR)-Discern Interaction Between Variables

There is general recognition that environmental issues of project management recently raise to one of the most difficult problems for managing today projects. [35] Conventional assumptions of project management are deficient due to not enough consideration of uncertainty in goals and methods and control everything against the initial fixed contract. The current project management approach causes project teams' work, as the most expert project resources, to accomplish their work with little regard to changing effective environments on the project. This strategic mistake occurs due to do not understand that the projects essentially are defined based on the environmental changes. This objective reality, lead project management attempts to increase project challenges and failure and finally, client dissatisfaction with regard to outcomes. It is a basic strategic change for managing today construction projects that is the concern of this paper.

In other words, many of the previous project management researches have produced long lists of variables or factors as project critical success factors without attention to differentiation between countries (at least between developing and developed countries) or between projects types. [19, 36] In fact, we need to broaden our understanding of project nature for increasing probability of project success. Whereas these factors are infinite based on the various experiences, there is a requirement to identify simple structure of fundamental factors that create projects behavior in specific condition. This study, focus on construction projects with continuous changing environments that there are big sector of project management attempts around the world, especially in developing countries.

We aim to identify relevant factors describing the construction project characteristics and attend to effective environments on the project behaviors that should be taken into account in the design of a performance management model for managing contemporary construction projects. Consider effect of environmental changes on projects behavior after understand basic structure of project behavior make a dynamic performance management model for predicting and managing any change on project performance. The model has been developed based on the literature analysis, interview findings and immediate experiences. This model could add to the material for academics and the normative literature for better understanding of construction projects behaviors and nature.

5.1. The conceptual model design

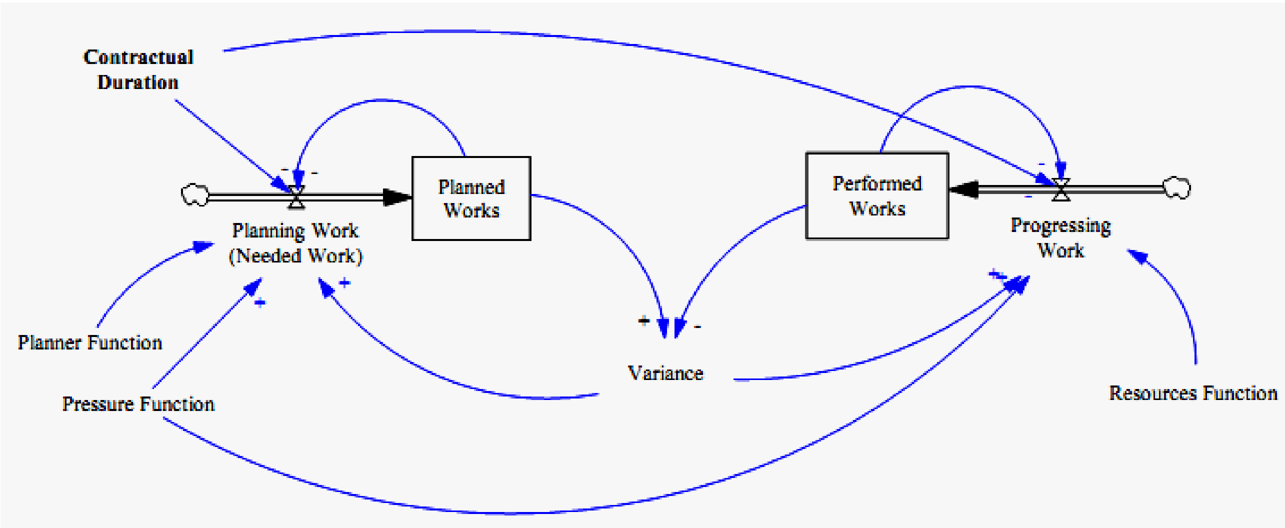
One of the famous behavioral patterns that utilize for analyzing systems behavior is competitive structure. This pattern describe competition between two distinctive parts of a system that when one part be lower than the other attempt to compete with another. This structure use for analyzing many social rivalry issues like competition between two people, two groups or two organizations. We apply the competitive structure as the basic structure of producing project behavior. In fact, we believe that decision making in projects environment is based upon competition between executing works (actual progress) and planned works (planned progress) in any projects.

The key point for utilizing competitive structure as basic structure to analyze projects behavior is perception of mutuality in projects behavior. In other words, there are two main parts in construction projects include planning part and executing part that form projects behavioral pattern. This model assume that performance of each part create to compete with another part. So, amount of work under progress as main mission of executing part descend if planning part could not make enough competition with it. In essence, every project has two growth engines that create project behavior by compete against each other.

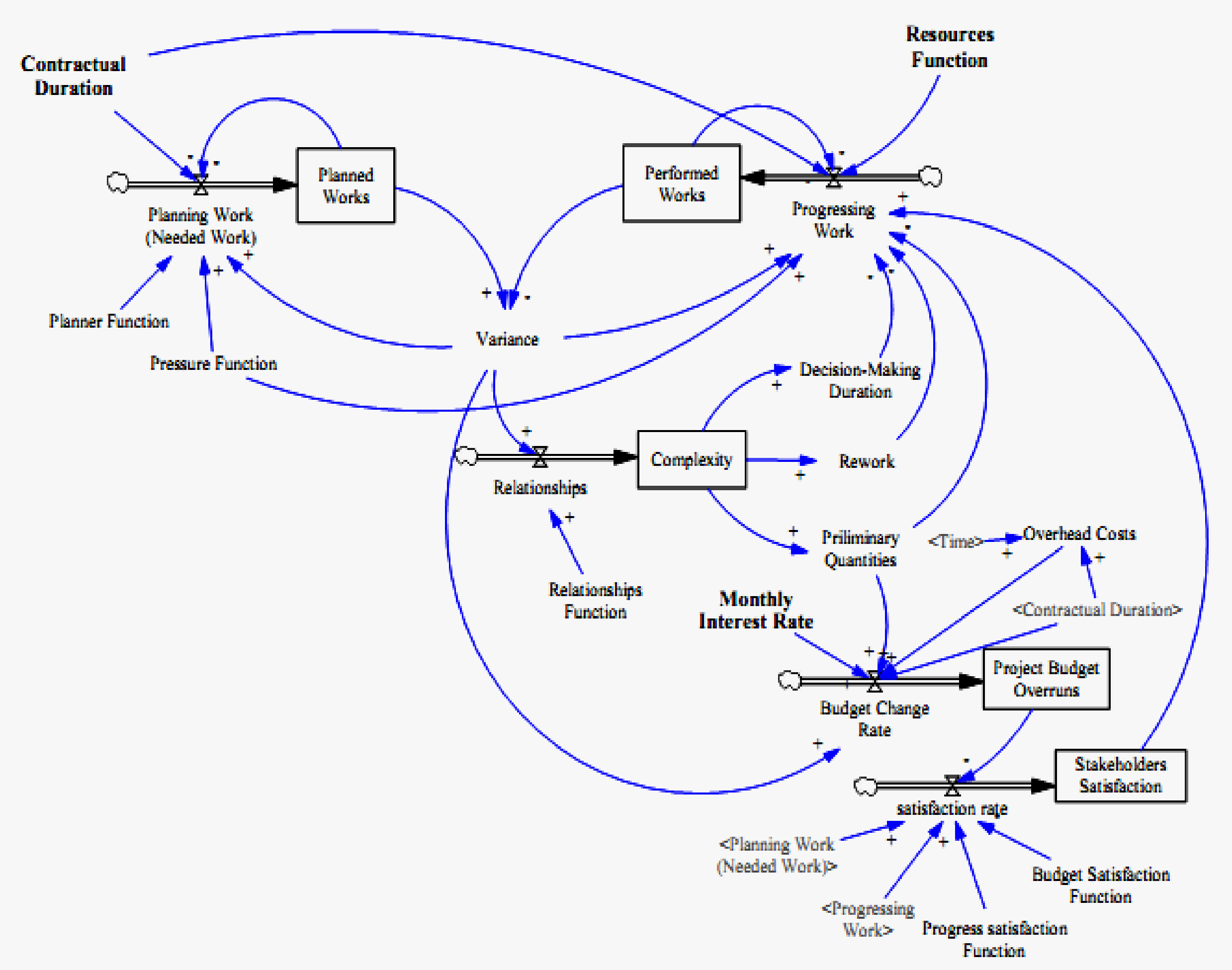
Whereas the competitive conditions continue during project lifecycle, potential continuous dynamic conditions, especially macro environment dynamisms, dominate over project behaviors. In essence, protean nature of construction projects as a fundamental characteristic of this type of projects creates dynamism in project assumptions that require a dynamic model for managing them. Therefore, a system dynamics model is a perfect tool for simulating project behaviors under the any changes. System dynamics is a methodology to study behaviors of complex systems. [37] A system dynamics model is a combination of feedback relationships that make system behaviors based on interactions between variables of a system during defined time steps. Many authors successfully applied the system dynamics methodology to project management researches including rework effect on project performance [38, 39, 40, 41, 42, 43], construction firm performance [44, 45], change management [3, 43, 46] and so on. Fig. 2.a illustrates a dynamic model of basic structure of projects that describe how the basic competitive structure creates two main part of project behaviors include planning work and progressing work.

In Fig. 2.a, planning work and progressing work are equal when planner function and resources function in the basic competitive structure of project can be match together. Furthermore, pressure function has a supportive role for balancing two competitors. The direction and signs of arrows indicate harmony or disharmony between connected variables changes. The behavioral equations of the basic competitive structure are shown in Appendix I-section A. The approach used to inferring causes of projects behaviors and interactions between project variables is co-authorship that described in the research methodology section. This approach uses to formulate assumptions and relationships in order to comparison model results with practitioners' experiences in case studies. Therefore, the main approach to determination the equations criteria is deductive method that is combination of theoretical considerations and empirical studies on practitioners' viewpoint.

However, many experiences around the world in projects environment-mentioned in the introduction-demonstrate inconsistency between these two functions. So, other policies utilize as supportive solutions for decrease the variance in project behavior. Based upon our studies, the first solution to manage project deviation in regard to its plan is increase project resources include quantity, new groups or new types. Adding project resources, especially in the form of new legal entity, lead projects to raise project elements and relationships between them that cause to increase project complexity. [32, 33] Our studies reveals that raise project complexity, specifically during project executing, have three consequences. First, prolongation of decision making processes due to more coordination requirement. (Equation 8) Equation numbers in parentheses refer to related empirical equations that shown in Appendix I. Second, increase rework rate in the project due to more inconsistency between project elements and decision making processes. (Equation 9) Third, add to project preliminary quantities due to increase rework rate. (Equation 10) Each of the consequences has reverse effect on progressing work and corrupts actual work trend and so help to incrementally raise the project variance. (Equation 20) More project variance cause to more budget requirement due to the effect of overhead costs and interest rate on project budget. (Equations 11 and 12) Cumulative project budget overruns decrease stakeholders' satisfaction (Equations 13, 14 and 15) and this new factor, due to re-assessment project management procedures, has an impedient impact on progressing work again. Fig. 2.b illustrates dynamic model of these imperfect policies in current project management methods.



a. Basic competitive structure that create projects behavior



b. Implement imperfect policies to manage contemporary construction projects variance

Fig. 2 Dynamic model of conventional construction projects management method

Therefore, in the circumstances that project complexity is one of the causes for project failure in today environment [47] do not consider contemporary construction project characteristics and root of their behaviors led the projects to more complexity in the last decade. Hence, although project management efforts developed in the last decades, rate of contemporary projects failure or challenges do not change considerably, as mentioned in the introduction. There is no enough time for trial and error approach to manage today projects. Also, we do not able find better project management strategy base on review case studies, whereas each project is unique and has different conditions. So, project management requires appropriate strategies and correct policies that is design base upon deep understand today projects nature.

We consider construction projects nature as a specific category in project management domain based on literature recommendations. [21, 22, 23, 25] Then, review common management policies in the literature, some case studies in our research, immediate experiences and interview with professionals. We find that common project management policies often focus on the project progressing work and project manager's attempts utilize to do more actual work in the project, whereas project define based on client needs and these needs could change during project execution. It is noticeable that the projects essentially create due to environmental changes or to get new opportunities, but after initiate a project major project team endeavors spend on internal aspects of project management and often do not consider initial project assumptions changes. Project changes are major cause of delay, disruption and conflicts in today project environment [48] that should be manage for achieving project success. So, project changes have a determinant role in contemporary project management and should be in focal point of project manager attentions.

There are two main causes to projects changes: environmental changes and internal changes. Internal changes usually are intended decisions for improving project executive methods, materials or managerial processes, but environmental changes have officious causes. In fact, the competitive structure of project behavior has two growth engines include planner function and resources function that construct two main section of the project behavior model (Fig. 2.a). Environmental changes drive planner function as external engine and internal changes drive resources function as internal engine. So, today construction project managers based upon understanding contemporary projects characteristics, specifically protean nature of construction projects, need manage two engines, simultaneously. Each engine constructed from various components, but we need simplify their elements to prepare project behavioral controllability.

We use imperfect conventional project management model, illustrated in Fig. 2.b, as a basic model to determine corrective policies that could change current projects behaviors. At first, project managers face with dynamic macro-environmental that occasionally change project assumptions and project stakeholders' expectations. So, there is a requirement to have an indicator that could displays project environmental dynamism to coordinate project internal decisions with external events. Therefore, project managers need to classify environmental issues that affect on project assumptions. PEST analysis (Political, Economic, Social and Technological analysis) show appropriate minimal classification from macro-environmental factors that use in the environmental scanning component of strategic management. Each macro-environmental factor evaluate by two criterion include effect percentage and change percentage.

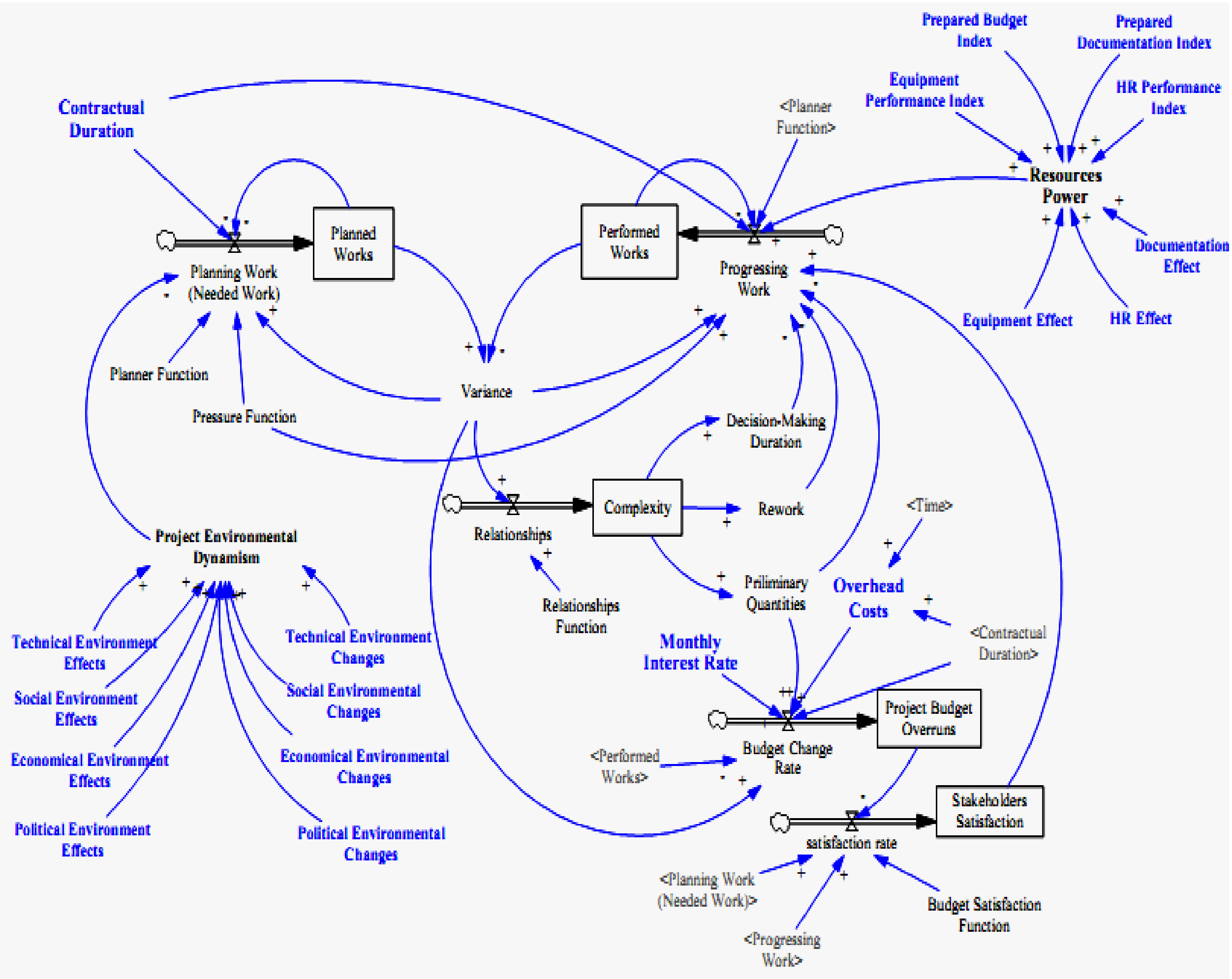
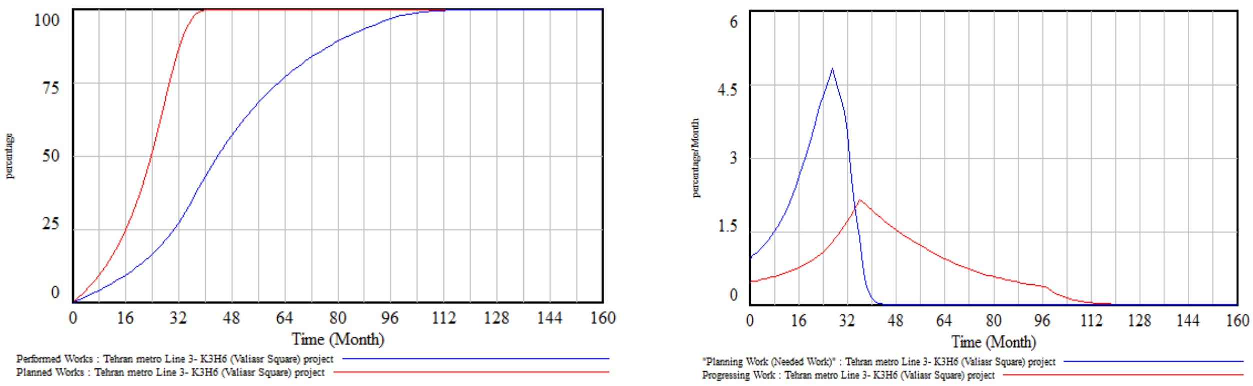
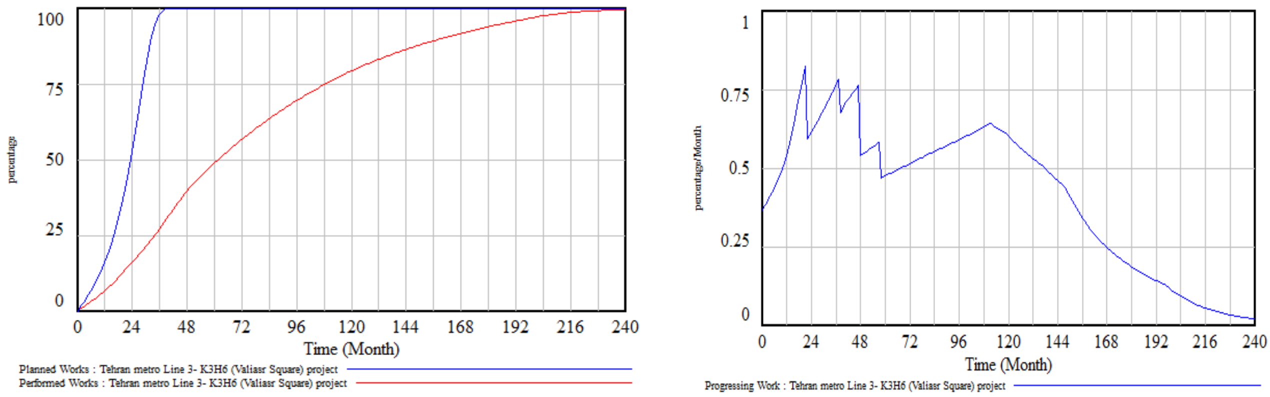


Fig. 3 Dynamic model of strategic performance management of contemporary construction projects based on inherent construction project characteristics (modified model)



a: Comparison planned work with simulated performed work

b: Rate of project completion



c: Effect of complexity on the performed work d: Effect of complexity on the project completion

Fig. 4 Effect of project complexity on the K3H6 project progressing work

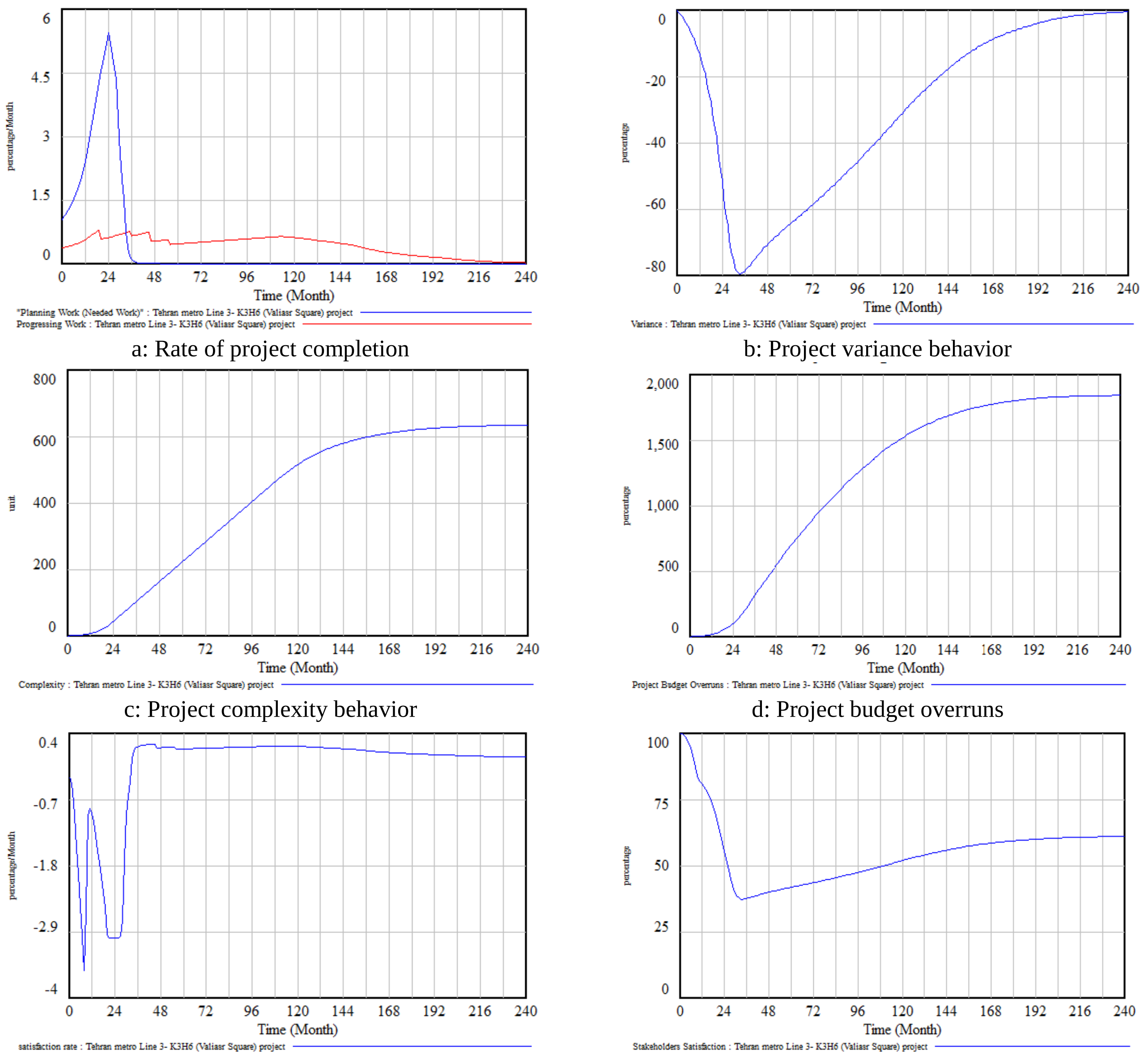
Project manager, firstly must indicate effective environments on project goals (client goals) and then estimate change percentage of each effective environment on project goals by sub-criterions. (Equation 16) Amount of environmental changes should be estimate base on sub-criterions analysis by judgment of project management team. Proper sub-criterions for estimating change percentage of each effective environment should infer based on the project teams perceptions of specific features associated with the project. For example anticipated inflation, general cash flow, client power on project finance and realistic estimation of cost and time might be sample of these sub-criterions for predicting of economic environmental change percentage. Also, technical uncertainty, similar experiences on project subject by consultant, similar experiences on project subject by client and innovation capability in technical assumption might be sample of other sub-criterions for predicting of technical environmental change percentage. It is noticeable that total percentages of effective environments must equal 100. Also, change percentage of each effective environment might be between -100 and +100 based on the weighted average negative or positive impacts. The related equations of this sector are shown in Appendix I-section C.

After environmental changes considerations that affect project assumptions, project manager should coordinate project internal decisions with external events. In fact, internal decisions are second main source that create project behaviors. So, there is essential requirement to understand fundamental factors that affect on progressing work. We study suggested critical success factors for project management [7, 8, 9, 11, 19, 23, 36] and then arrange various structured and semi-structured interviews with projects professionals in 37 construction projects in the scope of the study. Finally, we find all internal decisions make base upon project resources power that this internal indicator constructs from four main elements include budget preparation, documents preparation (availability of technical, legal, fiscal and methodological documents), human resources performance and equipments performance.

Similar to project environmental dynamism index, preparation or performance of each internal resource evaluate by two criterion include effect percentage and preparation percentage. Whereas budget affects on every construction projects its effect percentage is 100, but effect percentage of other resources are related to project characteristics. The effect percentage of each resource must evaluate by project management team base upon the particular project characteristics [29] or sensitivity of project works to each main type of resources. For example, equipment effect on road construction project performance is greater than building construction projects or documentation effect on innovation or mind projects is greater than manual projects.

Also, total percentages of resources effects must equal 100 and preparation percentage of each effective resource might be between 0 and 100 based on the average internal assessment of their productivity and reliability. In other words, to manage construction projects progressing work as internal engine of project management every project manager should determine more effective resources among the main four elements and adjusting their preparations respectively. These main four elements construct resource function of each construction project. (Equation 19) The equations of this sector are shown in Appendix I-section D.

Fig. 5 illustrates the dynamic model for managing and predicting of strategic performance of construction projects that have been inferred based on contemporary construction projects characteristics in continuous environmental changes. The suggested model is particularly appropriate for developing countries conditions that have more environmental dynamisms. This model triggers full potential power of basic competitive structure of project behaviors for managing today construction projects.



a: Rate of project completion
b: Project variance behavior
c: Project complexity behavior
d: Project budget overruns
e: Project stakeholders' satisfaction rate
f: Cumulative project stakeholders' satisfaction behavior

Fig. 5 Prediction of the K3H6 project behaviors based on changing the internal and external project circumstances

5.2. Model behaviors and testing

Comparison of model behavior to actual project behavior is one of testing methods for functional validation of system dynamic models. [49, 50] Therefore, we examine the model ability to reproduce construction projects behavior modes and prediction of next period of projects behavior in compared to their actual behaviors. The Tehran metro Line 3- K3H6 (Valiasr Square) project, as a sample among 37 construction projects in our study, is used to model validation. The model has been calibrated to actual data of the K3H6 project and simulated behaviors of this project compared to actual behavior. The K3H6 project was scheduled from May 04, 2008 to Nov. 04, 2011 for completion in 42 months.

In 30th month, the K3H6 project was scheduled to 89.7% physical complete, but was remained on 18.8% physical complete based on actual data that showed on model simulation in Fig. 4.a. The average performance or power of the four main elements of the project available resources based on the model structure has been evaluated during 6 months that calculated 60 percent, 55 percent, 75 percent and 65 percent for budget, documentations, human resources and equipments respectively. Then, the project variance behavior on completion date simulated based on insert average powers of available resources into the model.

The results of simulation showed that when project variance increase the project management team attempt to its correction by more resources allocation or do parallel operations. These conditions decrease project progressing work and make oscillation behavior in contractual duration due to more project complexity that illustrated in Fig. 4.d. In fact, increase project variance in regard to the plan cause to apply imperfect policies that increase management sensitivity near month 16. Then, combination of schedule pressure function as a positive loop and complexity function as a negative loop create oscillation behavior between months 16 to 48 that indicate ineffective managerial attempts to increase project progressing work. (Fig. 4.b and 4.d)

Moreover, the strategic performance management model predicts behavioral changes of the project variance, project complexity, project budget overruns, project stakeholders' satisfaction percent and rate of project completion at each next month based on average of available resources power and appraise opportunities and threats changes in macro-environments that illustrated in Fig. 5. Macro-environments changes in the K3H6 project have been estimated based upon predicted negative economic and social impacts mainly due to increase anticipated inflation and pessimistic general viewpoint regard to the project' client that have been quantified by -35 percent and -30 percent respectively. Also, positive political and technical impacts have been estimated chiefly due to predicted political emphasis and urban management volition for the project acceleration beside availability of technical experiences in similar urban projects that have been quantified by 70 percent and 15 percent respectively. Model equations for calculation of each variable presented in Appendix I (section A, B and C).

For model validation, these model predictions and the project simulated behaviors compared to the project actual results along two periods of time with 4 months each that presented in Table 2. Matching actual behaviors modes of the K3H6 project, as a sample, to the model simulations show model capability for predicting and managing the construction project behavior under changing circumstances. Construction project managers could trace effect of changing resources power on project behaviors for adjusting it. Also, create strategic view in project managers to continuous analyzing micro-environments change effects on project behaviors for choosing appropriate project policies is another capacity of the model.

Table 2 Comparison between model predictions and actual behaviors of the Tehran metro Line 3- K3H6 project

Time	Data Type	Progressing work/ month (%)	Cumulative performed works (%)	Project variance (%)	Project budget overruns (%)	Project stakeholders' satisfaction (%)
30th month	Actual data	0.68	18.8	70.9	180	High reduction
34th month	Model prediction	0.74	22.7	76.5	275	-2 (39.3 to 37.3)
34th month	Actual data	0.82	22.1	74.1	243	More reduction
38th month	Model prediction	0.67	25.3	74.9	355	0.6 (37.3 to 37.9)
38th month	Actual data	0.63	24.5	73.8	341	Without change

The structure and equations of strategic performance management model and the result of model predictions were presented to all project managers among 37 construction projects in the five categories. 89 percent of the managers believed, after some consideration and test, the model could notify crucial reactions in regard to change project environment by categorizing main elements that construct project behavior as dashboard instrument. These tests, demonstrate model ability to simulate construction projects behavior in continuous changing environment.

5.3. Structural model analysis

Model structure introduces two growth engines for managing construction projects. Firstly, environmental changes engine that should be used for finding new opportunities, activities, solutions or possible innovations in project assumptions. Secondly, resources power optimizer engine that should be used for adjusting combination of achievable resources in consistence with new environmental changes. The model structure helps to attend project management team to forecast future likelihoods and enhance their strategic perspective.

These potentials make long time view for project team and create new approach to discover any opportunities and risk in project environment. Consequently, project manager role will conform to inherent management mission for improving effectivity and efficiency. Results of the research and the variables that influence construction project behaviors could use to propose the methodology for planning and managing contemporary construction projects especially in developing country with increasingly rate of environmental changes.

6. Conclusion and Discussion

The paper includes two main parts. At first, the research analyzes inherent construction projects characteristics and secondly, have been developed a dynamic model for managing performance of contemporary construction projects. Construction projects often create due to emerge some changes in micro-environment. Therefore, it is possible that project assumptions be impermanent during the project implementation. So, construction projects success is dependent on continuous detecting any environmental changes for adjusting internal decisions based on latest changes in client expectations.

Consequently, a contractual project management model is inconsistence with protean nature of contemporary construction projects. Moreover, the component oriented approach in often project management standards like PMBOK guide cause to more project complexity and project challenges. Also, conventional research methods in project management based on case studies in order to find critical success factors for managing projects is trial and error approach that is inconsistence with some attribute in projects nature like project uniqueness. We believe that there is inappropriate approach to use general management tools for managing distinctive nature as project.

These issues reveals that definite definition of project scope to respond to client expectations is impossible and sure determine project activities list in frame of the static contract could cause to increase probability of project failure and client unsatisfactory. Therefore, it seems that to attain client needs and expectations should determine project scope and activities between periods of times that the effective environments on project needs have enough constancy through the period. Construction projects managers should estimate project requirements during these time sections by considering consistency between environmental changes and internal assumptions.

By the proposed project management methodology and its dynamic model as a tool, project managers in construction industry should pay their careful attention to main elements that construct internal and external of construction project environment based on the model structure. Model elements and interactions type between them formulate by co-authorship based on theoretical considerations and empirical studies on practitioners' experiences that presented in appendix I. The main advantage of the model is introducing restricted variables that create final project results. Results of the study will contribute to better decisions for practical actions in construction project environments and lead to more satisfactory outcomes. Furthermore, the study could make a basis for intended theoretical developments in the project management field.

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Appendix I: Model Equations

Section A- Basic Competitive Structure Equations

PLW (i) = (100/CD) . Fpl (CPL (i)) . Fpr (V (i)) (1)
CPL (i) = $\int PLW\ (i)$ (2)
PRW (i) = (100/CD) . Fr (CPR) . Fpr (V (i)) (3)
CPR (i) = $\int PRW\ (i)$ (4)
V (i) = CPR (i) – CPL (i) (5)

Where PLW (i)= planning work (needed work) (percentage/month); CD= contractual duration (month); Fpl= Planner look up Function (dimensionless); CPL (i) = Planned Works (percentage); Fpr = Pressure look up Function (dimensionless); V (i)= project variance (%); PRW (i)= progressing work (percentage/month); Fr = Resources look up Function (dimensionless); CPR (i)= Performed Works (percentage).

Section B- Imperfect Policies Equations

R (i) = Frl (V (i)) (6)
C (i) = $\int R\ (i)$ (7)
DMD (i) = IF (C (i) > 100) THEN (0.85) ELSE (1) (8)
RW (i) = IF (C (i) > 150) THEN (0.7) ELSE (1) (9)
PQ (i) = IF (C (i) > 200) THEN (0.8) ELSE (1) (10)
OC (i) = IF (t (i) - CD > 0) THEN (20/CD) ELSE (0) (11)
BR (i) = {(-V (i) . CD . MR (i)) /100} + {(-V . (1/PQ (i)))/100} + {OC (i) } (12)
BO (i) = $\int BR(i)$ (13)
SR (i) = Fbs (BO (i)) + Fps (PRW (i) – PLW (i)) (14)
PSS (i) = IN + $\int SR\ (i)$ (15)

Where R (i) = project relationships (unit/month); Frl = project relationships look up Function (dimensionless); C (i) = project complexity (unit); DMD (i) = decision making duration (dimensionless); RW (i) = project rework (dimensionless); PQ (i) = project preliminary quantities (dimensionless); t (i)= time step in project model (month); OC (i)= overhead costs (percentage/month); MR (i)= monthly money rate of interest for the project finance (percentage/month); BR (i)= budget change rate (percentage/month); BO (i)= project budget overruns (percentage); Fbs= budget satisfaction look up Function (dimensionless); Fps= progress satisfaction look up Function (dimensionless); SR (i)= project stakeholders’ satisfaction rate (percentage/month); IN (initial project stakeholders’ satisfaction) = 100 (%); PSS (i)= project stakeholders satisfaction (percentage).

Section C- Project Environmental Dynamism Equations

$$PED (i) = \{ (TE (i) . TC (i)) + (SE (i) . SC (i)) + (EE (i) . EC (i)) + (PE (i) . PC(i)) \} /10000 \quad (16)$$

$$RPLW (i) = (100/CD) . Fpl (CPL (i)) . Fpr (V (i)) . (1+PED) \quad (17)$$

Where TE (i)= technical environment effects (percentage); TC (i)= technical environment changes (percentage); SE (i)= social environment effects (percentage); SC (i)= social environment changes (percentage); EE (i)= economical environment effects (percentage); EC (i)= economical environment changes (percentage); PE (i)= political environment effects (percentage); PC (i)= political environment changes (percentage); PED(i)= project environmental dynamism (percentage); RPLW (i)= re-planning work (percentage/month).

Section D- Resources Power Equations

$$RE = \sum (DE + HE + EE) \quad (18)$$

$$RP (i) = (BI (i)/100) . \{ (DI (i) . (DE/ RE)) + (HI (i) .(HE/RE)) + (EI (i) . (EE/RE))\} \quad (19)$$

$$RPRW (i) = (100/CD) . Fpl (CPR) . (RP/100) . Fpr (V (i)) . RW (i) . PQ (i) . DMD (i) . (IF (PSS (i) > 70) THEN (1) ELSE (0.7)) \quad (20)$$

Where RE (sum of project resources effects on project performance) = 100 (%); RP (i)= project resources power (percentage); BI (i)= prepared project budget index (percentage); DI (i)= prepared project documentations index (percentage); DE= documentations effect on project performance (percentage); HE= human resources effect on project performance (percentage); EE= equipments effect on project performance (percentage); HI (i)= project human resources performance index (percentage); EI (i)= project equipments performance index (percentage); RPRW (i)= re-progressing work (percentage/month).